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Virtual gamma ray radiation sources through neutron radiative capture.

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INTRODUCTION

The countrate response of a gamma spectrometry system from a neutron radiation source behind a plane of moderating material doped with a nuclide of a large radiative neutron capture cross-section exhibits a countrate response analogous to a gamma radiation source at the same position from the detector. Using a planar, surface area of the neutron moderating material exposed to the neutron radiation produces a larger area under the prompt gamma ray peak in the detector than a smaller area of dimensions relative to the active volume of the gamma detection system.

DESCRIPTION OF THE ACTUAL WORK

Work was performed using a high purity germanium (HPGe) system and a plane of borated polyethylene, of dimensions 1.22 m × 1.22 m × 2.54 cm, to both thermalize and convert neutrons into 478 keV gamma rays through radiative capture. The 478 keV gamma peak is doppler broadened approximately ±6 keV due to emission during the recoil of the excited lithium-7 nucleus, as shown in Figure 1.

Counts were performed with a californium-252 (Cf-252) source at the same position with a disk of the borated polyethylene (of diameter 9.6 cm) near the dimensions of the detector crystal. The purpose was to provide a quantitative measurement of the effect from an increase in surface area of the plane facing the neutron source.

The countrate from the Cf-252 sample was also measured at positions traversing a path perpendicular to the symmetry axis of the HPGe detector, and the countrate from a cesium-137 (Cs-137) sample was also measured at the same positions separately. Counting times were scaled up as the distance of the sample to the detector increased to keep the statistical error of each count roughly the same. A Monte Carlo Neutron Particle (MCNP) simulation was also performed that simulated the response of the detector from the neutron radiation sample at positions along the same path.

The significance of this study is to cast light on a relatively easy and economical method to convert an already established gamma spectrometry system into a dual neutron-gamma detection system.

RESULTS

By taking the ratio of the areas under each peak for the plane and the disk, the measured build-up factor was 4.4 ± 0.3. A plot of the countrates versus energy is shown in Figure 1.

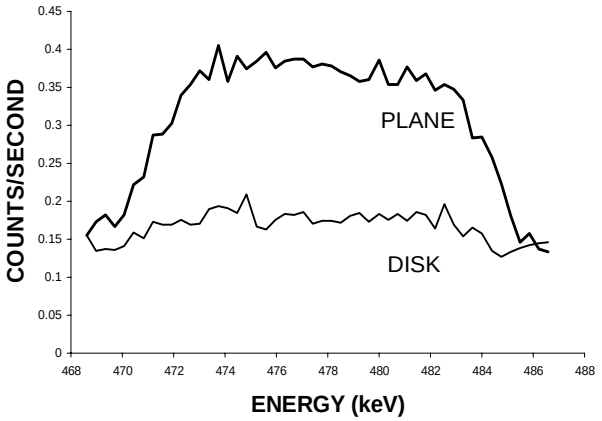

Fig. 1. The countrates of the plane and the disk versus energy of the photons counted, the distance from the source to the detector was 1 meter.

A plot of the countrates versus position on the axis of traversal for both samples is found in Figure 2 including MCNP results. In terms of countrate, the responses in the HPGe system from both samples are identical. Using the activity of the Cs-137 source and the ratio of areas under each peak, the response from the Cf-252 sample (2.2×10^5 n/s) can be said to be a doppler broadened 478 keV virtual gamma radiation sample with activity of 19.2 kBq.

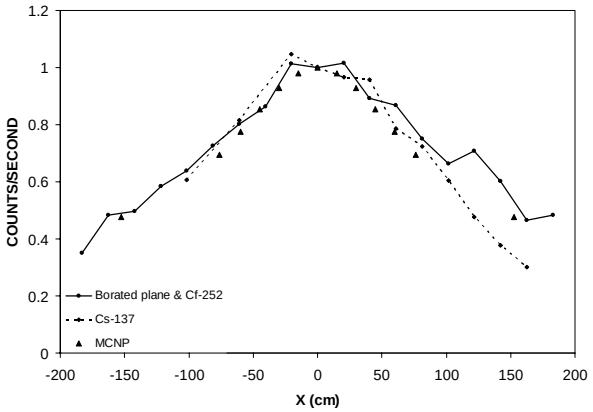

Fig. 2. Plot of countrates for both sources versus lateral position, normalized to 1 count per second on the axis of symmetry.